U.S. WEATHER BUREAU.

Florida hurricanes.

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FLORIDA HURRICANES

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During the 50-year period ending with 1935, 56 tropical cyclones either moved inland over Florida or passed near enough to cause damaging winds in coastal regions of the State. Of the 56 storms, 41 were of known hurricane intensity, while 15 were less-than-hurricane intensity or of doubtful hurricane intensity. Table 1 shows that these storms have been fairly well distributed throughout the 50-year period, although a greater number occurred during the 5-year period 1924–28 than during any other period of similar length. It will be noted that 10 storms occurred in this period as against an average of about half that number for a 5-year period. The greatest number of consecutive years without tropical storms was 2.

Although there is an average of one tropical storm a year for Florida as a whole, the average for any given part of the State is greatly less than this; and there is a marked difference in the number of storms that have occurred in the different parts of the State. Charles L. Mitchell (**1**) has shown that the average interval between tropical storms of hurricane intensity on the east coast of Florida, for each hundred-mile section of coast line, is 20 years, while the average interval between storms on the west Florida coast, for the same unit of coast line, is 13.9 years. The shorter interval on the west coast is due to the relatively great number of storms that have occurred between Cedar Keys, Fla., and Mobile, Ala. Only five tropical storms of hurricane intensity in the last 50 years have passed inland over the west coast of the peninsula between Fort Myers and Cedar Keys. Tampa is located in this section of the coastal region, and it has been more nearly exempt from hurricanes than any other coast city in southern Florida.

Table 1.—*Frequency of tropical cyclones by years*

Year	Of known hurricane intensity	Doubtful as to hurricane intensity	Total	Year	Of known hurricane intensity	Doubtful as to hurricane intensity	Total
1886	0	0	0	1911	1	0	1
1887	1	0	1	1912	1	0	1
1888	3	0	3	1913	0	0	0
1889	0	1	1	1914	0	0	0
1890	0	0	0	1915	1	0	1
1891	1	2	3	1916	1	1	2
1892	0	0	0	1917	1	0	1
1893	0	2	2	1918	0	0	0
1894	2	0	2	1919	1	0	1
1895	2	0	2	1920	0	0	0
1896	2	0	2	1921	1	0	1
1897	0	1	1	1922	0	0	0
1898	0	1	1	1923	0	0	0
1899	1	0	1	1924	3	0	3
1900	0	0	0	1925	1	0	1
1901	1	0	1	1926	3	0	3
1902	1	0	1	1927	0	0	0
1903	1	0	1	1928	3	0	3
1904	0	0	0	1929	1	0	1
1905	0	0	0	1930	0	0	0
1906	2	1	3	1931	0	0	0
1907	0	0	0	1932	0	2	2
1908	0	0	0	1933	1	3	4
1909	1	0	1	1934	0	1	1
1910	1	0	1	1935	3	0	3
				Total	41	15	56

Key West, on account of its exposed location in the Florida Straits, and Pensacola, on account of its exposed position to western Caribbean storms, have experienced more hurricanes than any other cities in the State. Key West has been in or near the paths of storms originating in both the Atlantic Ocean and the western Caribbean Sea, while all storms, but one, that passed inland over the west coast of the peninsula had their origin in western Caribbean waters. Several storms have recurved over western Cuba and struck the south coast, but all storms reaching the east coast from the Atlantic moved north of Cuba and through the Bahamas.

The northwestern Florida coast is especially exposed to the western Caribbean storms, and it has suffered from several hurricanes that moved through the Florida Straits out of the eastern Caribbean, or that crossed the Florida Peninsula and redeveloped great intensity after passing into the Gulf of Mexico. In this connection it should be said that all storms crossing the peninsula reach the opposite coast from which they entered with greatly decreased intensity. A notable example of a hurricane crossing the peninsula from the east and redeveloping great intensity over the Gulf was the Miami hurricane of September 18, 1926, which passed near Pensacola two days later, causing a wind velocity of 88 miles per hour. (Corrected to true velocity.)

Contrary to popular belief, as many hurricanes have occurred in Florida in October as in any other month, this in spite of the anomalous fact that no hurricane has passed inland over the east coast of Florida during October in the last 56 years (**1**). All October storms have either struck the west or extreme south coasts, or have recurved to the northeastward off the lower east coast. The decided tendency for tropical cyclones to develop over the western Caribbean Sea near the end of the hurricane season is shown by the fact that, of 22 Florida storms that had their origin in the western Caribbean in the last 50 years, 13 occurred in October and 2 in November. One of these was the famous "loop" hurricane of October 1910, that twice swept over Key West and Habana (**1**).

The storm of October 30–November 8, 1935, was the most unusual hurricane to visit the Florida east coast. While practically all storms of the latter part of the season have formed over the western Caribbean Sea or in the Gulf of Mexico and moved in a northeasterly direction, this storm formed over the Atlantic east of Bermuda. It moved, first, in a west-northwesterly direction as a moderate disturbance to a point some distance off Cape Hatteras, where it turned abruptly south-southwestward, increased to hurricane intensity, and continued on a straight course to Great Abaco Island, Bahamas. Here it made another abrupt turn to west-southwest and passed inland over the city of Miami on November 4, about 1:45 p. m., attended by hurricane winds, which did extensive damage. It continued its west-southwest course and passed into the Gulf north of Cape Sable, and was attended by a limited area of hurricane winds some distance out into the Gulf. It then began a slow recurve to north and northeast and

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then east, with diminishing intensity, and finally dissipated over the Gulf some distance west of Tampa on November 8.

The most belated tropical cyclone of record to reach the coast of the United States developed over the western Caribbean and moved northeastward through the Yucatan Channel to the lower west coast of Florida, where it passed inland on November 30, 1925. It passed off the upper east coast of Florida on December 1. This storm was attended by winds of hurricane force on the extreme lower west coast and by excessive rains throughout the peninsula. A remarkable 24-hour rainfall of 15.10 inches occurred at Miami in connection with this storm.

Frequency of tropical cyclones, by months, for Florida is shown in table 2. This table is based on the 50-year record ending with 1935.

TABLE 2.—*Frequency of tropical cyclones by months*

	June	July	Aug.	Sept.	Oct.	Nov.	Total
Of known hurricane intensity	2	3	7	16	11	2	41
Doubtful as to hurricane intensity	3	1	1	2	7	1	15
Total	5	4	8	18	18	3	56

A study of the chart of hurricane paths shows that tropical cyclones are most likely to occur on the east coast of Florida during the months of August and September, and on the west coast during October. The chances of a hurricane reaching the Florida coast in any given year are about one in four for the east coast and one in two for the west coast. It should be said, however, that these storms are much more likely to occur on the lower east coast, extreme lower west coast, and the northwest coast. The upper east-coast section, in which Jacksonville is located, and the middle west-coast section, in which Tampa and St. Petersburg are located, have been relatively free from hurricanes, and the chances of a hurricane occurring in those sections in any given year are very slight. Since the center of a hurricane, as a rule, must pass within 50 miles of a place to cause winds of hurricane force, the chances of hurricane winds occurring at any given place in any given year are considerably less than is indicated by the chart of hurricane paths. The chances of hurricane winds in any year for several of the important cities of the State are roughly indicated in table 3.

TABLE 3.—*Chances of winds of hurricane force in any given year*

City	Chances	City	Chances
Jacksonville	1 in 50	Fort Myers	1 in 20
West Palm Beach	1 in 20	Tampa	1 in 30
Miami	1 in 20	Pensacola	1 in 10
Key West	1 in 10		

The occurrence of tornadoes in the northeast quadrant of a hurricane area was an interesting phenomenon observed in connection with the Florida hurricanes of September 10, 1919 (**3**), and September 28, 1929 (**4**). Both of these storms passed through the Florida Straits, and, when located off the extreme lower southwest coast, caused tornadoes along the lower east coast. In the case of the second storm, several tornadoes occurred from Miami northward to Stuart. These tornadoes all moved from the southeast to the northwest with the hurricane winds prevailing at the time, and the indications were that they developed over the ocean as waterspouts. Their paths extended only a few miles inland.

Tornadoes were also observed in connection with the storm of October 4–5, 1933, which moved northeastward just southeast of the Florida Keys and the extreme southeastern Florida mainland. The tornadoes, several in number, occurred between Miami and Fort Lauderdale, moving northeastward, while the storm center was moving northeastward some distance out in the ocean to the eastward, thus placing them in the northwest quadrant of the cyclone. The paths were narrow in width and short. One occurred in the western suburbs of Miami, causing $5,000 in property damage.

Of all the hurricanes that reached the Florida coast in the last 56 years, only eight can be classed as "great", both as to intensity and diameter (**1**). Several storms not so classed, however, were attended by destructive winds and loss of life, including the hurricane of September 1935, in the Florida Keys-Cedar Keys section; it was a hurricane of "great" intensity but of small diameter when it crossed the Florida Keys.

The "great" Florida hurricanes of the last 56 years were as follows:

June 1886: Apalachicola-Tallahassee section.

July 1916: Mobile-Pensacola section.

August 1880: West Palm Beach-Lake Okeechobee section.

September 1919: Key West section.

September 1926: Miami-Okeechobee-Pensacola sections.

September 1928: West Palm Beach-Okeechobee section.

October 1910: Key West-Fort Myers section.

October 1916: Mobile-Pensacola section.

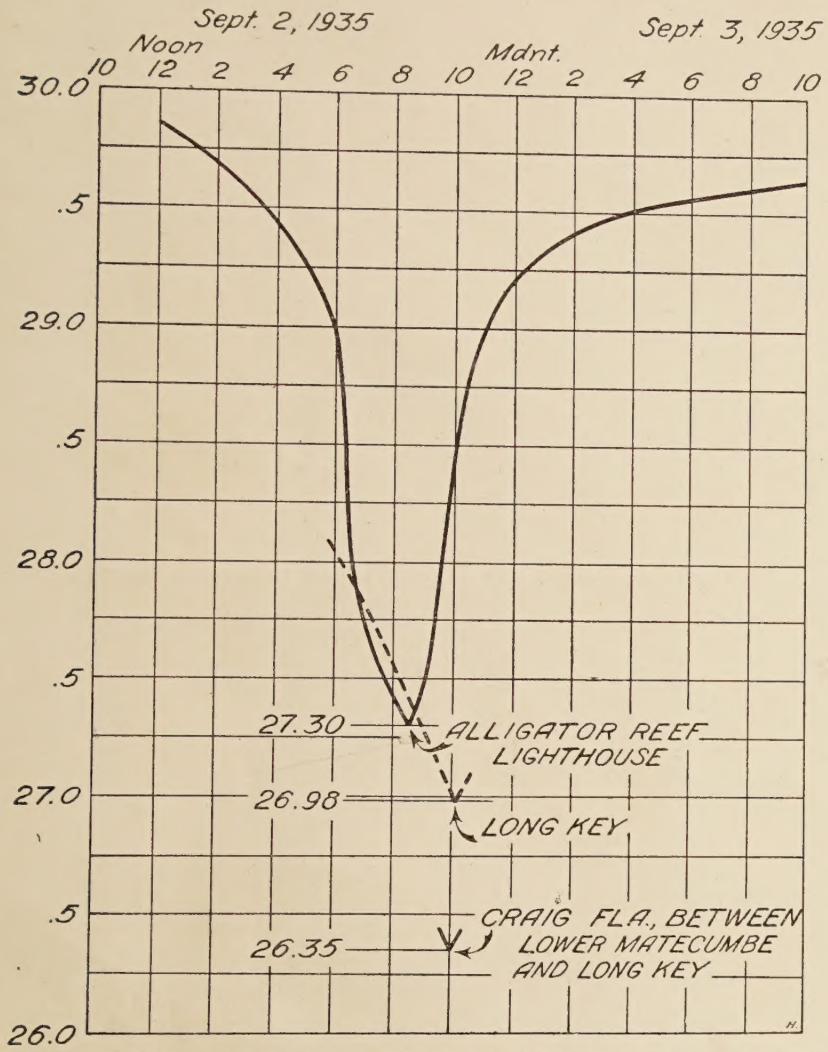
The lowest sea-level barometer readings of record in the United States, and the Western Hemisphere, occurred in connection with the storm on the Florida Keys of September 2, 1935, when a well authenticated reading of 26.35 inches occurred at Craig, Fla. A corrected reading of 26.98 was recorded on Long Key, and 26.76 on Lignumvitae Key in connection with this storm. The reading of 26.35 inches is 1.08 inches lower than the previous United States low, which was recorded in the West Palm Beach hurricane of September 16, 1928, and 1.26 inches lower than the Miami hurricane of September 18, 1926.

The storm of September 2, 1935, was of rather small diameter when it crossed the Florida Keys, where the path of damage was only about 40 miles in width, but for violence it is one of the outstanding hurricanes of our recorded history. Engineers estimate by formula from the character of damage that the wind velocity approximated 200 miles per hour. More than 30 miles of the Florida East Coast Railway track was destroyed, the keys were overflowed by storm tides in this area to a depth of from 4 to 12 or more feet, and more than 400 persons were killed, mostly by drowning.

While the barometer fell to 27.43 inches in the West Palm Beach hurricane, as compared with 27.61 inches in the Miami hurricane, it was evident from an inspection of the storm areas that a higher wind velocity occurred in the Miami storm. The trees left standing in the Miami area, even in the densest jungles, were completely defoliated, while many trees in the Palm Beach area, after the 1928 storm, were only partly defoliated. Apparently, the gradient in the West Palm Beach storm, which previously had caused a wind velocity of 160 miles per hour at San Juan, P. R., decreased before the disturbance reached the Florida coast. The diameter of the vortex of the Miami hurricane was 13 miles, while that of the

West Palm Beach hurricane was approximately 25 miles. The highest recorded wind velocity for the United States, 138 miles per hour, by three-cup anemometer registration (125 miles corrected true velocity), occurred at Miami Beach during the Miami hurricane (5). The much greater loss of life attending the West Plam Beach hurricane was not caused by the direct force of the wind, but by the flood waters from Lake Okeechobee.

A thorough inspection of the storm areas in the Miami and West Palm Beach hurricanes, which rank with the greatest of record in so far as wind velocity and loss of life and property are concerned, clearly indicates that hurricanes of major intensity do not cause serious structural damage to properly constructed buildings. This

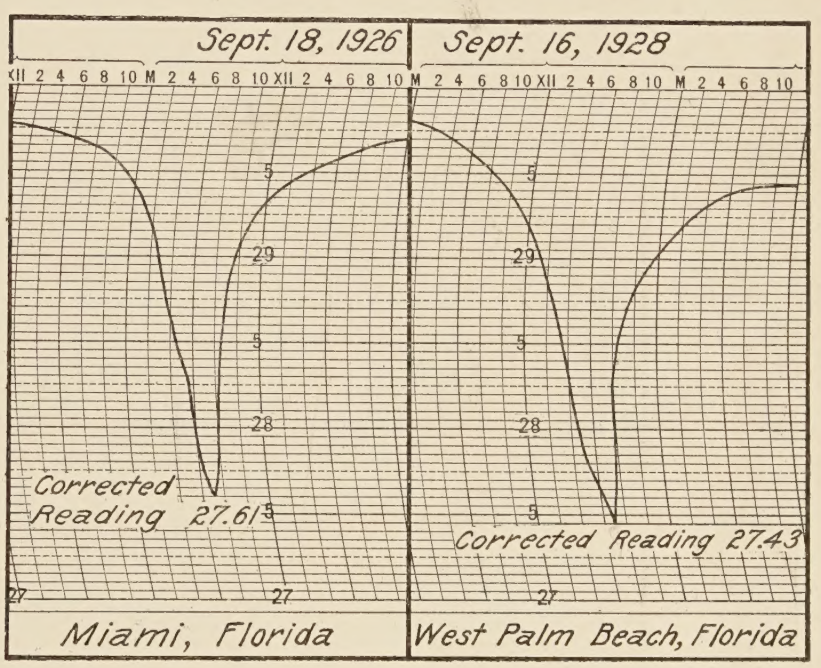


Barogram of Florida Keys Hurricane, September 2, 1935 (constructed from barometer readings).

statement does not apply to buildings near an ocean beach, where foundations may be undermined or the beach badly eroded by storm tides. Several substantial houses near the ocean at Miami Beach were undermined and collapsed in the hurricane of September 18, 1926, but substantial buildings only one block from the ocean escaped serious structural damage. Practically all buildings were damaged by water, resulting from broken windows and doors, or from damaged roofs. In Miami there were several frame residences, with shingle roofs, which were erected when the city was first laid out, in 1896. These houses escaped, not only structural damage, but serious water damage, while many hundreds of concrete-block houses of flimsy construction were demolished. The same conditions were observed at Palm Beach, West Palm Beach, and Lake Worth, which were directly in the path of the September 16, 1928, hurricane. Office buildings of the better type, ranging in height from 10 to 20 stories, were damaged principally by water. There were a number of substantial residences that were seriously damaged by debris from other buildings or by falling trees, but, with these exceptions, the writer observed no substantially-constructed buildings in which the occupants were not safe during the entire duration of the Miami and West Palm Beach hurricanes. In Key West, there are a considerable number of frame buildings that have withstood all the hurricanes of the last 55 years at that place without serious damage. One frame structure on the Government reservation has safely passed through all the Key West hurricanes since 1846.

Observations of the storm areas of the severe hurricanes on the east coast of Florida in 1926, 1928, and 1929 warrant the following statement.

If a building is properly constructed, including the proper type of roof and roofing material, and is securely anchored to the proper kind of foundation, it will not sustain serious structural damage in a hurricane of major intensity. If, in addition to the proper construction, all windows, doors, and vents are protected by storm shutters, the building should withstand strong hurricane winds



with practically no damage. Such a building can be constructed at only a moderate increase of cost above that for the usual type of construction, and the saving in storm insurance will repay the extra cost in a few years time.

However, observations of the character of the damage done by the Florida Keys storm of September 2, 1935, indicate that structural damage of a serious nature would doubtless have resulted to buildings of the most substantial construction now in use. Storms of such unusual violence will doubtless occur very infrequently, probably not oftener than once in a century, and are too rare to justify inclusion of provisions for protection against them in hurricane building codes.

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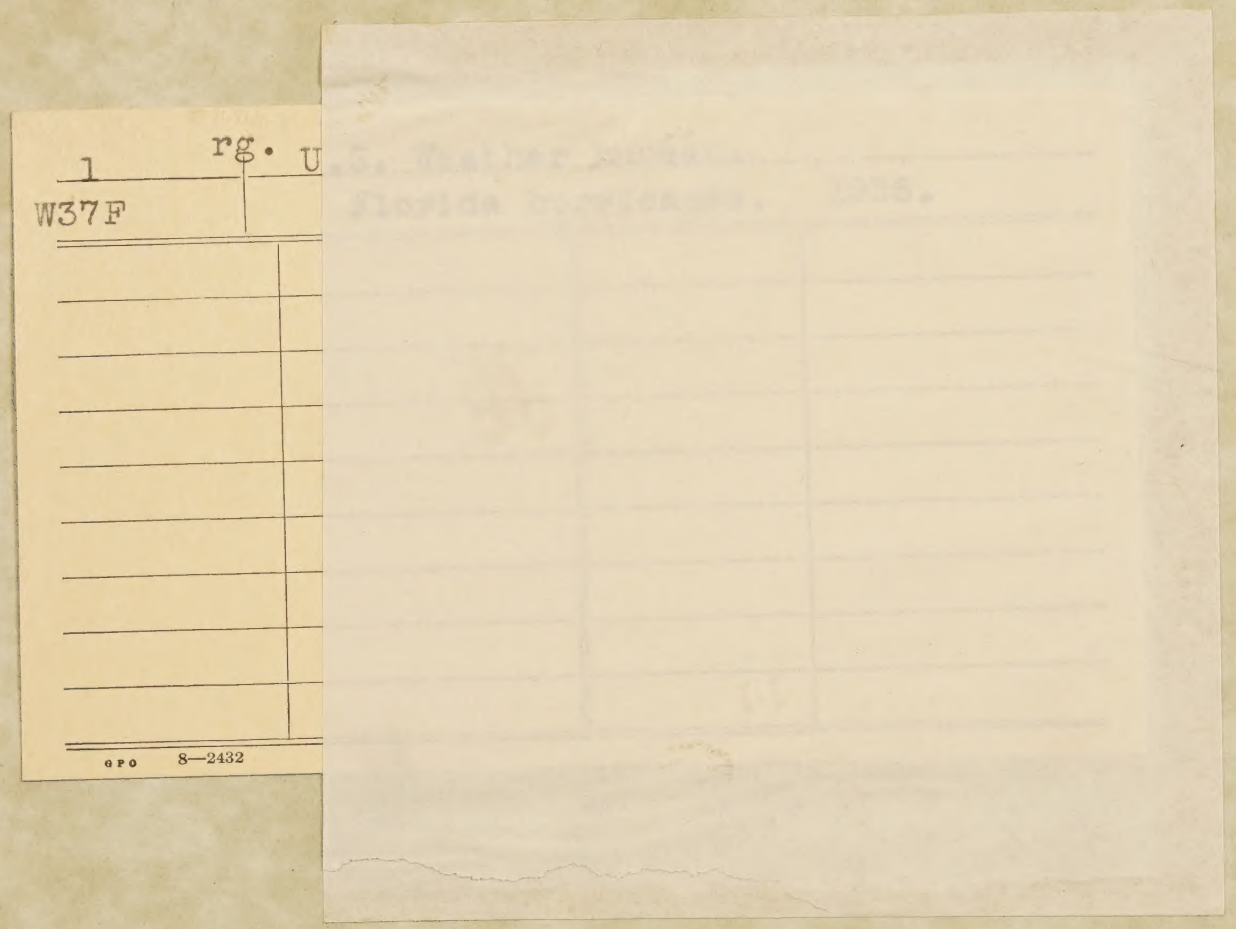
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